

CLAIMS

What is claimed is:

1. A process comprising:
patterning a carbon-containing hard mask over a substrate with a resist; and
surface treating the substrate to remove residual resist under conditions that
are selective to the hard mask and to the substrate.
2. The process of claim 1, wherein patterning the carbon-containing hard mask
includes patterning amorphous carbon, and wherein surface treating includes using
an aqueous ammonium hydroxide and hydrogen peroxide solution.
3. The process of claim 1, wherein patterning the carbon-containing hard mask
includes patterning amorphous carbon, and wherein surface treating includes using
an aqueous ammonium hydroxide and hydrogen peroxide solution in an
 $H_2O:NH_4OH:H_2O_2$ concentration ratio from about 100:3:2 to about 5:1:2.
4. The process of claim 1, wherein patterning the carbon-containing hard mask
includes patterning amorphous carbon, and wherein surface treating includes using
an aqueous ammonium hydroxide and hydrogen peroxide solution in an
 $H_2O:NH_4OH:H_2O_2$ concentration ratio from about 5:1:1 to about 5:1:2.
5. The process of claim 1, wherein patterning the carbon-containing hard mask
includes patterning amorphous carbon, and wherein surface treating includes using
an aqueous ammonium hydroxide and hydrogen peroxide solution in an
 $H_2O:NH_4OH:H_2O_2$ concentration ratio from about 100:1:2 to about 100:3:2.

6. The process of claim 1, wherein patterning the carbon-containing hard mask includes patterning amorphous carbon, and wherein surface treating includes using an aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio from about 100:1:1 to about 100:3:3.

7. A process comprising:

patterning a carbon-containing hard mask over a substrate with a resist; and surface treating the substrate to remove residual resist under conditions that are selective to the hard mask and to the substrate, wherein surface treating includes an aqueous ammonium hydroxide and hydrogen peroxide solution that is applied in a time range from about 2 minutes to about 45 minutes.

8. The process of claim 7, wherein surface treating includes surface treating with an aqueous ammonium hydroxide and hydrogen peroxide solution that is applied in a temperature range from about room temperature to about 70° C.

9. The process of claim 7, wherein patterning the carbon-containing hard mask includes patterning amorphous carbon, wherein surface treating includes surface treating with an aqueous ammonium hydroxide and hydrogen peroxide solution that is applied in a temperature range from about room temperature to about 70° C.

10. The process of claim 7, wherein patterning the carbon-containing hard mask includes patterning amorphous carbon, wherein surface treating includes:

surface treating with an aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio from about 5:1:1 to about 100:3:2; and

a temperature range from about room temperature to about 70° C.

11. The process of claim 7, wherein patterning the carbon-containing hard mask includes patterning amorphous carbon, wherein surface treating includes:

surface treating with an aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 100:3:2; a time of about 10 minutes; and a temperature of about 55° C.

12. A process comprising:

patterning an amorphous carbon hard mask with a resist stack over a substrate, the resist stack including:

at least one antireflective coating disposed over the hard mask, selected from a dielectric antireflective coating and a bottom antireflective coating; and

a photoresist layer disposed over the at least one antireflective coating; and

surface treating the substrate to remove residual photoresist under conditions that are selective to leaving the hard mask, the at least one antireflective coating, and the substrate.

13. The process of claim 12, wherein surface treating includes rinsing the photoresist with a solution selected from aqueous ammonium hydroxide and hydrogen peroxide solution, aqueous sulfuric acid and citric acid solution, aqueous sulfuric acid and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, ozone with dilute hydrogen fluoride, and combinations thereof.

14. The process of claim 12, wherein surface treating includes using an aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio from about 5:1:1 to about 100:3:2, a time range from about 2 minutes to about 45 minutes, and a temperature range from about room temperature to about 70° C.

15. The process of claim 12, wherein surface treating includes using an aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 100:3:2, a time range from about 10 minutes to about 20 minutes, and a temperature range from about 30° C to about 60° C.

16. A process comprising:

patterning an amorphous carbon hard mask with a resist stack over a substrate, the resist stack including:

at least one antireflective coating disposed over the hard mask, selected from a dielectric antireflective coating and a bottom antireflective coating; and

a photoresist layer disposed over the at least one antireflective coating; and

surface treating the substrate to remove residual photoresist under conditions that are selective to leaving the hard mask, the at least one antireflective coating, and the substrate, wherein surface treating includes using an aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 100:3:2, and a temperature of about 55° C.

17. The process of claim 16, wherein surface treating includes a surface treating time of about 5 minutes.

18. The process of claim 16, wherein surface treating includes a surface treating time of greater than about 5 minutes to about 10 minutes.

19. The process of claim 16, wherein surface treating includes a surface treating time of greater than about 10 minutes to about 20 minutes.

20. The process of claim 16, wherein surface treating includes a surface treating time of greater than about 20 minutes to about 30 minutes.

21. A process comprising:

patterning an amorphous carbon hard mask with a resist stack over a substrate, the resist stack including:

at least one antireflective coating disposed over the hard mask, selected from a dielectric antireflective coating and a bottom antireflective coating; and

a photoresist layer disposed over the at least one antireflective coating; and

surface treating the substrate to remove residual photoresist under conditions that are selective to leaving the hard mask, the at least one antireflective coating, and the substrate, wherein surface treating includes using an aqueous sulfuric acid and citric acid solution for a time of about 10 minutes, and a temperature of about 55° C.

22. The process of claim 21, wherein surface treating includes using an aqueous sulfuric acid and citric acid solution in an H₂O:H₂SO₄:C₆H₄O₇ concentration ratio of about 100:3:2.

23. The process of claim 21, wherein surface treating includes using an aqueous sulfuric acid and citric acid solution in an H₂O:H₂SO₄:C₆H₄O₇ concentration ratio of about 100:2:2.

24. A process comprising:

patterning a carbon-containing hard mask with a resist over a substrate; and

surface treating the substrate to remove residual resist under conditions that are selective to leaving the carbon-containing hard mask, wherein surface treating includes surface treating with a rinse solution selected from aqueous ammonium hydroxide and hydrogen peroxide solution, aqueous sulfuric acid and citric acid solution, aqueous sulfuric acid and hydrogen peroxide solution, Aleg 820 solution,

ozone with dilute ammonium hydroxide, ozone with dilute hydrogen fluoride, and combinations thereof.

25. The process of claim 24, wherein surface treating includes surface treating with a rinse solution:

in a majority proportion aqueous ammonium hydroxide and hydrogen peroxide solution; and

in a minority proportion at least one of aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride.

26. The process of claim 24, wherein surface treating includes surface treating with a rinse solution:

in a majority proportion aqueous ammonium hydroxide and hydrogen peroxide solution;

in a minority proportion at least one of aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride; and the process further including:

surface treating for a time range from about 2 minutes to about 45 minutes.

27. The process of claim 24, wherein surface treating includes surface treating with a rinse solution:

in a majority proportion aqueous ammonium hydroxide and hydrogen peroxide solution;

in a minority proportion at least one of aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride; and the process further including:

surface treating for a temperature range from about room temperature to about 70° C.

28. The process of claim 24, wherein surface treating includes surface treating with a rinse solution:

in a majority proportion aqueous ammonium hydroxide and hydrogen peroxide solution;

in a minority proportion at least one of aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride; and the process further including:

surface treating for a time range from about 2 minutes to about 45 minutes, and

for a temperature range from about room temperature to about 70° C.

29. A process comprising:

patterning a carbon-containing hard mask with a resist over a substrate; and surface treating the substrate to remove residual resist under conditions that are selective to leaving the carbon-containing hard mask, wherein surface treating includes:

in a plurality proportion aqueous ammonium hydroxide and hydrogen peroxide solution; and

in a minority proportion at least two of aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride.

30. The process of claim 29, wherein surface treating includes surface treating for a time range from about 2 minutes to about 45 minutes, and a temperature range from about room temperature to about 70° C.

31. The process of claim 29, wherein surface treating includes surface treating with a rinse solution:

the plurality proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 100:3:2; and
the minority proportion including aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 5:1:1.

32. The process of claim 29, wherein surface treating includes surface treating with a rinse solution:

the plurality proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 100:3:2;
a first minority proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 5:1:1; and
a second minority proportion of at least one solution selected from aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride.

33. The process of claim 29, wherein surface treating includes the rinse solution:

a plurality proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 100:3:2;
a first minority proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 5:1:1;
a second minority proportion of at least one solution selected from aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride; and

wherein the second minority proportion is less than the first minority proportion.

34. The process of claim 29, wherein surface treating includes the rinse solution:
 - a plurality proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 100:3:2;
 - a first minority proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 5:1:1;
 - a second minority proportion of at least one solution selected from aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride; and

wherein the second minority proportion is less than the first minority proportion; and the process further including:

 - surface treating a time range from about 2 minutes to about 45 minutes; and
 - a temperature range from about room temperature to about 70° C.

35. A process comprising:
 - patterning an amorphous carbon hard mask with a resist stack over a substrate, the resist stack including:
 - at least one antireflective coating disposed over the hard mask, selected from a dielectric antireflective coating and a bottom antireflective coating; and
 - a photoresist layer disposed over the at least one antireflective coating; and
 - surface treating the substrate to remove residual resist under conditions that are selective to leaving the hard mask, the at least one antireflective coating, and the substrate, wherein surface treating includes an ozone-containing solution.

36. The process of claim 35, wherein surface treating includes the ozone-containing solution and further including at least one of aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride.

37. A process comprising:

patterning an amorphous carbon hard mask with a resist stack over a substrate, the resist stack including:

at least one antireflective coating disposed over the hard mask, selected from a dielectric antireflective coating and a bottom antireflective coating; and

a photoresist layer disposed over the at least one antireflective coating; and

surface treating the substrate to remove residual resist under conditions that are selective to leaving the hard mask, the at least one antireflective coating, and the substrate, wherein surface treating includes a sulfuric acid-containing solution.

38. The process of claim 37, wherein surface treating includes surface treating with the sulfuric acid-containing solution and further including at least one of aqueous citric acid, aqueous oxaloacetic acid, aqueous acetic acid, and an acetic functional group aqueous acid.

39. A process comprising:
patterning a carbon-containing hard mask over a substrate with a photoresist;
surface treating the substrate to remove residual photoresist under conditions
that are selective to the hard mask and to the substrate; and
dry etching the substrate through the hard mask.

40. The process of claim 39, wherein the carbon-containing hard mask includes
amorphous carbon, and wherein surface treating includes surface treating using an
aqueous ammonium hydroxide and hydrogen peroxide solution.

41. The process of claim 39, wherein patterning the carbon-containing hard
mask includes patterning amorphous carbon, and wherein surface treating includes
surface treating using an aqueous ammonium hydroxide and hydrogen peroxide
solution, wherein surface treating includes surface treating for a time range from
about 2 minutes to about 45 minutes, and wherein surface treating also includes
surface treating at a temperature range from about room temperature to about 70° C.

42. The process of claim 39, wherein surface treating includes surface treating
using an aqueous sulfuric acid and citric acid solution in an H₂O:H₂SO₄:C₆H₄O₇
concentration ratio of about 100:3:2 to about 100:2:2, a time of about 10 minutes,
and a temperature of about 55° C.

43. A composition comprising:
water;
ammonium hydroxide; and
hydrogen peroxide, wherein the composition is configured for removing dry-
developed residue from carbon-containing resist and to be selective to amorphous
carbon.

44. The composition of claim 43, wherein the aqueous ammonium hydroxide and hydrogen peroxide solution is in a majority proportion, the composition further including:

in a minority proportion at least one of aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride.

45. The composition of claim 43, wherein the aqueous ammonium hydroxide and hydrogen peroxide solution is in a majority proportion, the composition further including:

in a minority proportion at least one of aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride.

46. The composition of claim 43, wherein the rinse solution includes:

a majority proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 100:3:2; and
a minority proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 5:1:1.

47. A composition comprising:

in a plurality proportion an aqueous ammonium hydroxide and hydrogen peroxide solution; and

in minority proportion at least two of aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride, wherein the composition is configured to removing dry-developed residue from carbon-containing resist and to be selective to amorphous carbon.

48. The composition of claim 47, wherein the plurality proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 100:3:2;

wherein the minority proportion includes:

a first minority proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 5:1:1; and

a second minority proportion of at least one solution selected from aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride.

49. The composition of claim 47, wherein the plurality proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 100:3:2;

wherein the minority proportion includes:

a first minority proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 5:1:1; and

a second minority proportion of at least one solution selected from aqueous sulfuric acid and citric acid solution, aqueous sulfuric and hydrogen peroxide solution, Aleg 820 solution, ozone with dilute ammonium hydroxide, and ozone with dilute hydrogen fluoride; and

wherein the second minority proportion is less than the first minority proportion.

50. The composition of claim 47, wherein the plurality proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 100:3:2;

wherein the minority proportion includes:

a first minority proportion of aqueous ammonium hydroxide and hydrogen peroxide solution in an H₂O:NH₄OH:H₂O₂ concentration ratio of about 5:1:1; and
a second minority proportion of a piranha etch composition; and
wherein the second minority proportion is less than the first minority proportion.